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PATENT SPECIFICATION

619,495

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COMPLETE SPECIFICATION

Improvements in the Art of Treating a Liquid such as Milk and Other Bacteria Affected Liquids

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the treatment of a liquid such as milk or other liquid affected by bacillus subtilus or similarly behaving bacteria, and especially the sterilization or pasteurization of milk or other similarly bacteria affected liquids. The term liquid also includes liquid materials of the type stated.

In the usual or "holder method" of pasteurization, milk is heated to a temperature of 143° Fahrenheit and held at this temperature for 30 minutes. The milk is then cooled for storage or bottling. Usually the bacteria content is reduced to about one per cent. of the starting value, but if the time be less than 30 minutes the bacteria content is noticeably greater. When the milk is held at that temperature for a longer time, a cooked flavour is usually present and the apparent cream volume is reduced. While the most pathogenic bacteria in milk are destroyed by this standard treatment the pasteurization temperature employed is nearly optimum for the growth of certain thermophilic bacteria, while many thermoduric bacteria, such as Bacillus subtilis, survive the treatment quite well.

So called "S.T.H.T." (short-time, high-temperature) methods, in which the milk is heated quickly to 161° F. and held at that temperature for not less than 15 seconds, have been the subject of experiment for some time. In some cases, the milk is spread in a thin film on heated plates and quickly pumped over cooling plates. In an analogous (short time) process, the milk is passed between two electrodes to which 60 cycle voltage is applied. Since milk is a good conductor (resistivity of 200 ohms for a centimeter cube) current flows through the milk and generates heat. Difficulties with the electrodes have kept this method from becoming popular. (Carbon electrodes are somewhat porous and the minute particles of matter which are retained in the pores thereof may affect the flavour of the milk. When metal electrodes, including those constituted of stainless steel and coin silver are employed, pronounced darkening followed by the formation of a greenish substance takes place about the metal).

There also exists a suggestion for destroying bacteria in flowing liquid such as milk and for eliminating the propagation of bacteria by sterilizing the liquid, the liquid being passed through a container and there subjected to an electrostatic flux between electrodes. This process is not a heating process but based on the theory that bacteria, like other materials, have a fundamental point of vibration, or point of resonance, with the electrical energy, and at which the bacteria is destroyed; and bacteria and other deleterious matters are destroyed by means of the radiant, electrical energy, developed through the use of a high voltage electro-static flux concentration or field.

In methods employing a pasteurization temperature of 161° F., 16 seconds appears to be the longest time at which milk may be held at this temperature without altering its taste and apparent cream volume, and even under ideal conditions the bacteria count may be, and usually is, higher than it is in milk pasteurized by the more conventional holder method.

Accordingly, the principal object of the present invention is to provide a

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highly effective, and extremely rapid electrical method of, and apparatus for, sterilizing or pasteurizing milk and other similarly bacteria affected beverages or liquid without altering the taste or nutritive values of such materials.

Another and related object of the invention is to provide a novel "flash" method of heating a continuous flow of milk or similarly bacteria affected liquid to a temperature which is positively lethal to bacteria, as by means of radio frequency energy, and one which in its practice dispenses with the use (and disadvantages incident to the use) of carbon or other "contact" electrodes.

Another and commercially important object of the present invention is to provide a new and practical method of maintaining, increasing or restoring the apparent cream volume of milk, the normal creaming properties of which might be, or have been influenced by processing or storage.

Other objects and advantages, together with certain preferred details of construction and procedure, will be apparent and the invention itself will be best understood by reference to the following specification and to the accompanying drawing, wherein:

Figure 1 is a schematic view, partly in section, of one form of apparatus which may be employed in practising the "flash" pasteurization method of the present invention, and

Figure 2 is a chart illustrative of the results (in terms of bacteria count) achieved with the present invention, as compared with prior methods.

Stated briefly, the foregoing and other objects are achieved in accordance with the invention by a method of treating a liquid such as milk or other liquid affected by bacillus subtilis or similarly behaving bacteria which comprises applying a high frequency electrostatic field to a stream of the liquid so as to heat the liquid to a temperature in excess of 175° F., and then cooling the liquid to 135° F. or below, while flowing from the electrostatic field, all within a period of time not exceeding one second.

A method embodying the invention provides for projecting a stream of the liquid to be treated through a high frequency field of an intensity sufficient to heat it, for a fraction of a second only, to a temperature which may approach the boiling point of the liquid and which in any event is positively lethal to most bacteria. The temperatures which may be employed in pasteurizing milk in accordance with the invention are preferably not less than 175° F. and no higher than of the order of 212° F., and the period during which the milk is subjected to such a temperature is preferably substantially less than one second. A temperature of approximately 205° F. ensures thorough pasteurization of milk and, at the same time, allows a commercially satisfactory tolerance or avoidance of temperature in excess of the boiling point (212.3° F.).

As stated above a rapid cooling is required to keep the cooking taste to a minimum and fat output to a maximum. Any sort of artificial cooling may be applied but in a preferred form the required rapid cooling to approximately 135° F. is effected by admitting the hot liquid stream into a vacuum chamber which, conveniently, may be mounted adjacent to the radio frequency applicator in line with the nozzle or pipe from which the liquid is projected into the electric field.

The duration of the heating and cooling cycles determine the apparent cream volume and the taste of milk. A total absence of any cooked flavour is achieved, in accordance with the invention, when milk is first heated to a temperature within the indicated range and then cooled to a temperature of 135° F. or less, all within a period of about one second or less. In some cases (as when the pasteurizing temperature employed is higher than 185° F.) cooling the milk immediately to a mere 135° F. may reduce noticeably apparent cream volume. Accordingly, when the apparent cream volume is of commercial significance (as it is when non-homogenized milk is to be marketed in glass bottles), it is preferable to cool the milk instantly to a temperature substantially lower than 135° F. The general rule is:—The higher the pasteurization temperature, the greater the amount of heat which must be abstracted to achieve a given high apparent cream volume. Thus, when, in accordance with the invention, milk which has been subjected to a pasteurization temperature of 205° F. and then cooled to a temperature of the order of 86° F., all within a period of less than one second, the apparent cream volume is not affected adversely, whereas milk from the same supply and subjected to the same pasteurization temperature, when cooled to a temperature of, say, 117° F. within the same period of time, may exhibit a relatively lower apparent cream volume. On the other hand, if the pasteurization temperature be 200° F., an excellent cream level is achieved when the milk is cooled rapidly to a temperature of the order of 117° F. By employ-

ing "flash" heating and rapid cooling but in accordance with this invention to somewhat lower temperatures than those indicated above, it is even possible to achieve an apparent cream volume better than that of raw milk from the same supply.

In the interest of economy, the raw milk or other untreated liquid is preferably preheated, by any conventional means, to a temperature of, say, 140° F. before being subjected to the electric field. Thus, as shown in the drawing, raw milk from a source controlled by the tap 1 may be allowed to flow over a hot water coil 3 and the warm milk collected in a trough or reservoir 5 having an outlet pipe 7 therefrom which leads directly to the electric field applicator, indicated generally at 9.

The applicator 9 is preferably of the type described and shown in the specification No. 598,486, wherein separate electrodes, here designated 11, 13 and 15, and a glass tube 17 or other support for the said electrodes are so designed, positioned and arranged that a jet or stream 19 of liquid from the pipe 7 may be projected through the electric field between the electrodes without coming in contact with any part of the applicator. (As explained in the specification No. 598,486, there is thus no danger of overheating the outer or peripheral portion of the stream, as would be the case if the fluid were to flow in contact with the inner surface of the conduit 17).

In the instant case, the stream of milk 19 is circular in cross-section and the electrodes 11, 13 and 15 comprise three metal rings or bands arranged one above the other in collinear and symmetrical relation about the stream. If desired, however, the milk may be projected from the pipe 7 in the form of ribbon made up of one or more streams of milk, in which case, if desired, the electrodes may comprise two or more pairs of flat metal plates (not shown) arranged one pair above the others and with the electrodes of each pair opposite one another and parallel to the major faces of the ribbon. In any event, the energy supplied to the electrodes from a suitable source of radio frequency energy, here exemplified by a concentric transmission line 21, should be of an intensity sufficient instantaneously to heat the milk, within the area circumscribed by the electric field, to a temperature which is lethal to any pathogenic organisms therein. As previously set forth, a temperature of about 205° F. is recommended for commercial installations. The quantity of radio frequency power required to achieve such a temperature is discussed elsewhere in this specification.

While the electric field may be applied to the milk 19 *in vacuo*, it is preferable, usually, to maintain the atmosphere about the stream at atmospheric pressure. In the latter case, the conduit 17 through which the stream is passed may be formed with one or more vents 23 and, below the vent or vents, with a funnel 25 into the mouth of which the stream 19 is directed. The mouth of the funnel, being normally filled with the liquid, serves as a vacuum tight seal between the vacuum cooling system and the open conduit 17.

The cooling system shown in Figure 1, comprises a chamber 27 which is coupled by a connection 34 with a vacuum pump (not shown) through a pipe 29 and a vertically arranged cooling jacket or condenser 31. The condenser may be cooled by flowing cold raw milk, supplied through a cold milk intake 35, between the walls of the condenser and thence out through a connection 36 with the tap 1 of the preheater 3. In passing through the condenser 31, the milk is heated by the hot vapour from the vacuum chamber 27.

The temperature to which milk or other similarly bacteria affected liquid is cooled by admitting it into a vacuum chamber depends upon the degree of vacuum maintained in the said chamber, and in this connection it may be noted that a vacuum of air pressure 32 millimeters of mercury corresponds with a temperature of about 86° F., one of 83 millimeters of mercury corresponds with about 117° F. and 132 millimeters of mercury corresponds with about 135° F.

The hot milk entering the vacuum chamber is cooled because some of the energy is used in vapourizing part of the water in the milk. The water vapour is drawn out of the chamber by the vacuum pump. Since, usually, it is not desirable to remove any water from the milk, the condenser is mounted in the vertical direction so that the condensate runs back into the chamber 27 through the pipe 29 and is mixed with the milk before being drawn off through the valve 33.

The percentage of water removed by evaporation may be calculated from the equation:

Percentage of water lost by evaporation $= \frac{\Delta F}{9.7}$ where ΔF is the difference in temperature between the hot milk entering the vacuum chamber and the boiling temperature established by the degree of vacuum, expressed in degrees Fahrenheit. Where the milk entering has a

temperature of 205 degrees and the milk is cooled to, say, 86 degrees, 12.2 per cent. of its volume would be lost if it were not caught and returned by the condenser.

The electrical energy requirements calculated from the specific heat of milk are approximately the same as observed in reducing the invention to practice, i.e.:

Energy (watt-minutes per U.S.A. quart) $=36.7\Delta_1F$ where Δ_1F is the temperature increment obtained with radio frequency. If milk be preheated to 140° F. and radio frequency power be used to elevate the temperature to 205° F., the temperature increment is 65 degrees, and the energy required is 2380 watt-minutes per quart. Thus, one kilowatt of power will pasteurize 25.2 quarts per hour and a 100 kilowatt oscillator will pasteurize 2520 quartz or 5040 pounds per hour.

The radio-frequency of the electric energy employed in practising the invention is by no means critical and may comprise any convenient frequency of from about 20 megacycles per second and upward. The results charted in Figure 2 of the drawings were achieved with the oscillator tuned to a frequency of the order of 30 megacyles per second.

In the chart of Figure 2 the ordinate is calibrated in terms of bacteria (standard plate count) and the abscissa is marked in degrees Fahrenheit to designate a wide range of milk pasteurization temperatures. The bacteria count of raw milk from a single source was 7,910,000 and 10,990,000. (These two samples were taken at the same time. The variation is usual in biological assays). As indicated by the two dots, when a sample of this milk was pasteurized by the conventional holder method (i.e. 143° F./30 minutes) the bacteria count was reduced to about 60,000 per cubic centimeter. As indicated by the two triangular indicia, the bacteria count of milk from the same batch when pasteurized by a " S.T.H.T." electrical method (160° F. for 16 seconds) was of the order of 90,000 to 100,000. On the other hand, and as shown by the solid line *a*, the same raw milk pasteurized by the radio frequency " flash method " of the present invention at the recommended temperature of 205° F. showed a bacteria count of only 100. In this case the time it took to raise the temperature of the milk from its pre-heated temperature of about 135° F. to the pasteurization temperature of 205° F. was estimated to be about 0.067 of a second, and the cooling time was estimated to be 0.2 of a second.

The lines *b* and *c* on Figure 2 refer to the phosphatase tests which were made on each sample. The phosphatase test is highly regarded by health authorities as a quick means of determining that milk has been heated. The state of the enzymes changes at temperatures determined by the holding time. Thus, in the example illustrated, if the treatment is carried only to a temperature below 175° F. (line *b*) a positive reaction is obtained while if carried to 180° F. (line *c*) or above, a negative reaction is obtained. It is quite possible to have a high bacteria count with a negative phosphatase record. However, it is used as a test method a great deal so that it is most desirable that any new technique yields a negative phosphatase reaction. Such a negative reaction was achieved, and this fact is indicated on Figure 2.

It will now be apparent that the present invention provides an extremely rapid and highly effective method and apparatus for pasteurizing milk and other beverages.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Method of treating a liquid such as milk or other liquid affected by bacillus subtilis or similarly behaving bacteria which comprises applying a high frequency electrostatic field to a stream of the liquid so as to heat the liquid to a temperature in excess of 175° F., and then cooling the liquid to 135° F or below, while flowing from the electrostatic field, all within a period of time not exceeding one second.

2. Method according to Claim 1 wherein the temperature to which the liquid is heated is 205° F.

3. Method according to Claim 1 or Claim 2, which comprises heating the liquid from one temperature above room temperature and below its boiling point to another higher temperature which is still below, the boiling point, and then cooling said liquid, all within a period of time not exceeding one second in duration.

4. Apparatus for applying the method according to any of Claims 1 to 3, comprising a reservoir for said liquid connected through a space to a vacuum cooling chamber for projecting liquid from said reservoir through said space into said vacuum chamber, and means mounted intermediate said reservoir and said vacuum chamber for applying a high frequency electrostatic field for heating said liquid in its passage through said space.

5. Apparatus according to Claim 4,

wherein means are provided for pre-heating said liquid with the heat abstracted from the heated liquid in said vacuum chamber.

6. Apparatus according to Claim 4 or Claim 5 comprising means for pre-heating milk to a temperature of the order of 140° F.; a reservoir for the preheated milk having an outlet from which the milk emerges in the form of a continuous jet; a high frequency electric field applicator mounted about the path of said jet and adapted to heat said jet in passing to a temperature of the order of 205° F.; a chamber into which said hot milk is received; and means for establishing and maintaining a vacuum of air pressure from 132 to 32 millimetres of mercury in said chamber.

7. Apparatus for the treatment of milk according to Claim 4, substantially as herein described and illustrated.

Dated this 5th day of September, 1945.

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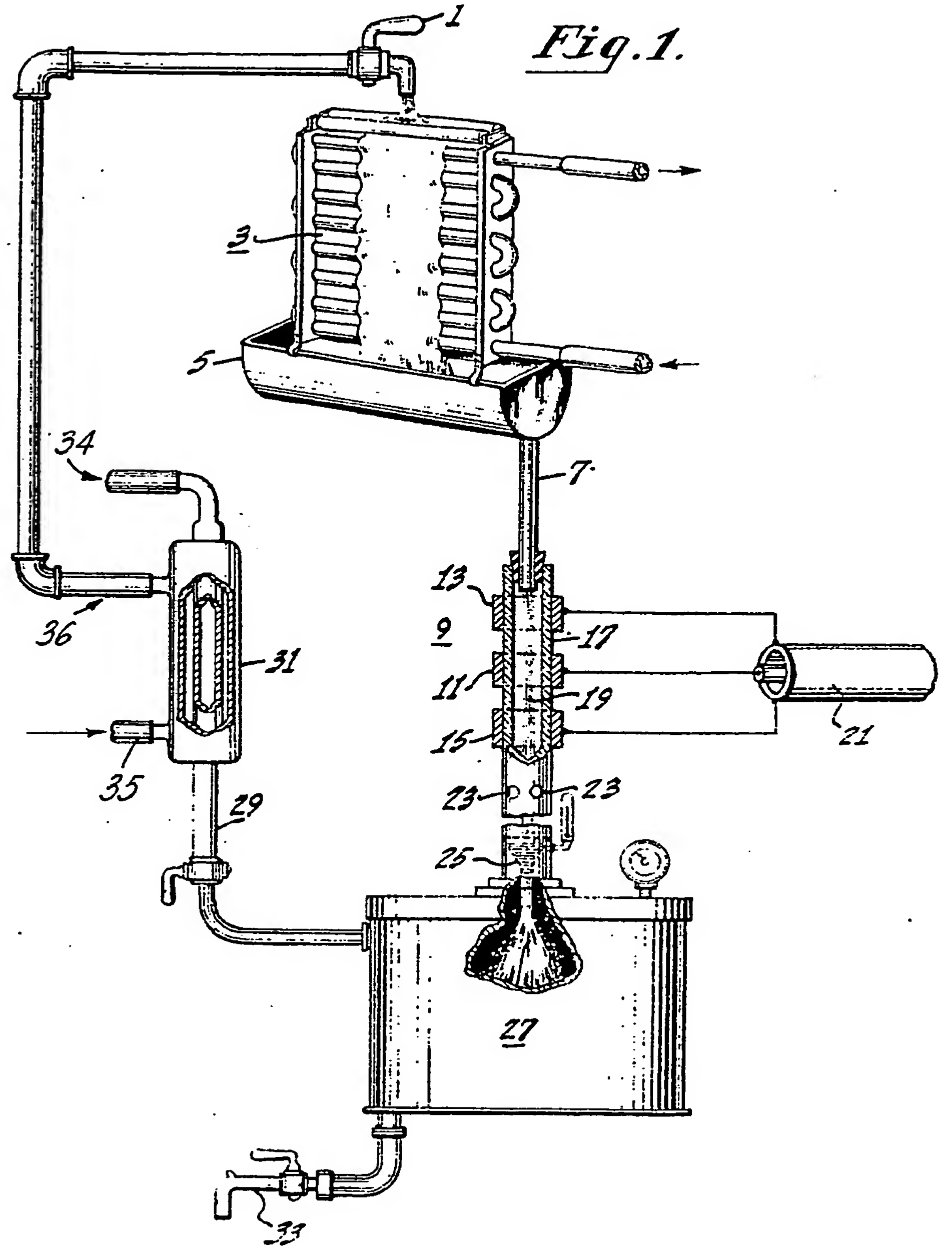
Fig. 1.



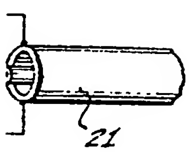

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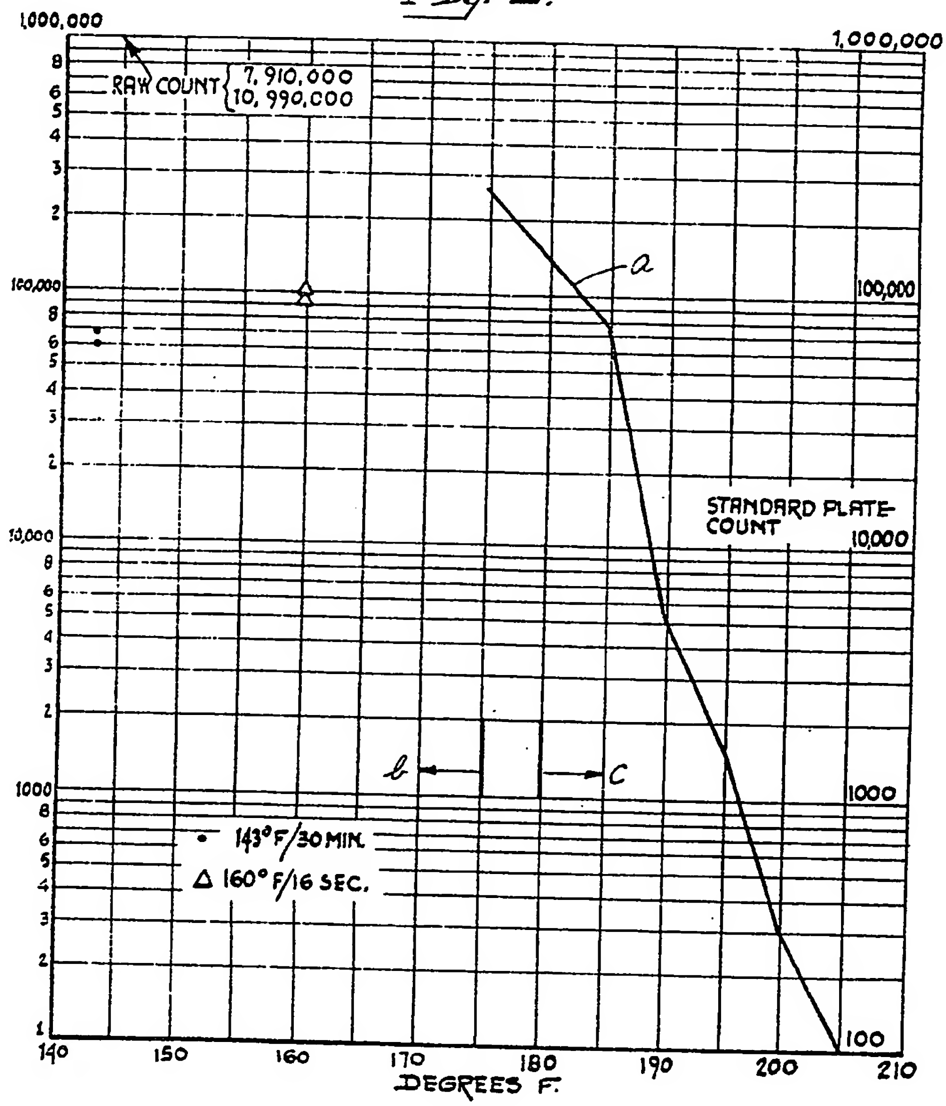
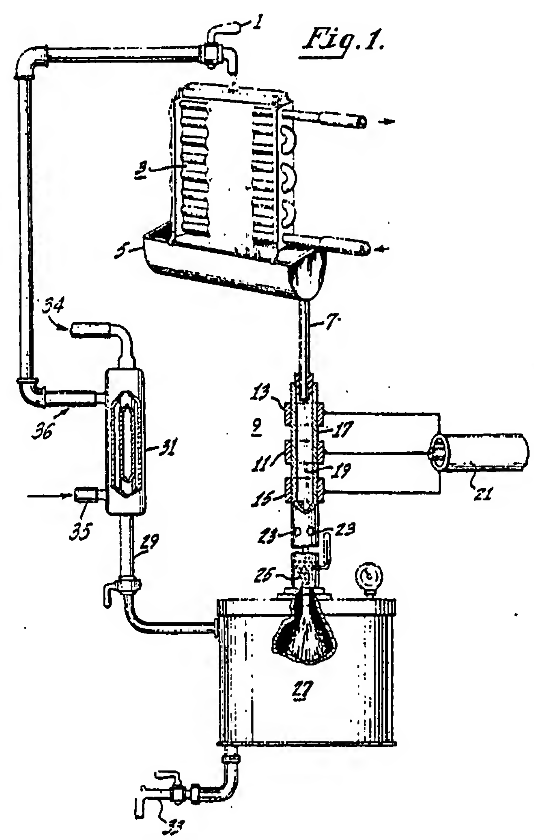
Fig. 2.


1,000,000
RAW COUNT
7,910,000
10,990,000
1,000,000
a
100,000
100,000
STANDARD PLATE COUNT
10,000
10,000
b
C
1000
1000
143°F/30 MIN.
△ 160°F/16 SEC.
100
140
150
160
170
180
190
200
210
DEGREES F.

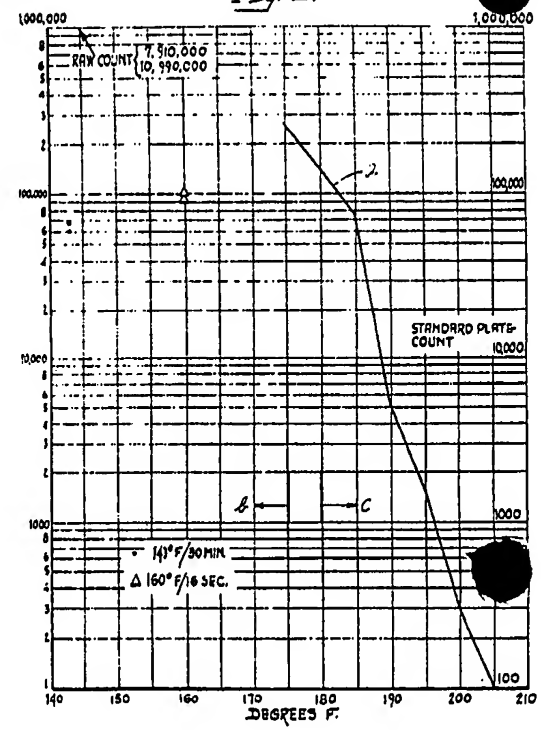
SHEET 1

Fig. 1.



SHEET 2

Fig. 2.



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